GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

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Date: October 18, 1976

Project Title: Biomass Conversion for Total Energy Utilization

Project No: E-21-603

Project Director: Dr. D. C. Ray

Sponsor: Georgia Institute of Genetics (thru the Board of Regents)

Agreement Period: From 10/1/76 Until 9/30/77

Type Agreement: Grant

Amount: $12,000

Reports Required: Semi-Annual Progress
Annual Progress

Sponsor Contact Person (s):

Technical Matters	Contractual Matters (thru OCA)
Dr. A. P. Sheppard Administration Building Campus	Office of Contract Administration Administration Building Campus

Defense Priority Rating: None

Assigned to: Electrical Engineering (School/Laboratory)

COPIES TO:

Project Director	Library, Technical Reports Section
Division Chief (EES)	Office of Computing Services
School/Laboratory Director	Director, Physical Plant
Dean/Director—EES	EES Information Office
Accounting Office	Project File (OCA)
Procurement Office	Project Code (GTRI)
Security Coordinator (OCA)	Other
Reports Coordinator (OCA)	

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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: 1/25/78

Project Title: Biomass Conversion for Total Energy Utilization

Project No: E-21-603

Project Director: Dr. D.C. Ray

Sponsor: Georgia Institute of Genetics (thru the Board of Regents)

Effective Termination Date: 12/31/77

Clearance of Accounting Charges: 12/31/77

Grant/Contract Closeout Actions Remaining: none

- _ Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ______

Assigned to: Electrical Engineering (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
✓Security Coordinator (OCA)
Reports Coordinator (OCA)

Library, Technical Reports Section
Office of Computing Services
Director, Physical Plant
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other ______

CA-4 (3/76)

E-21-603

SEMI-ANNUAL PROGRESS REPORT

BIOMASS CONVERSION FOR TOTAL ENERGY UTILIZATION

Dr. Dale C. Ray

April 6, 1977

The research program in biomass conversion is directed to the study of the broad spectrum of energy conversion processes which utilize biodegradation or thermal decomposition to convert organic matter to useful end products such as fuel, fertilizer, food, or other commercially useful end products. The organic matter which serves as the feed product typically would be classified as waste or at best a low value byproduct of other money making operations on a farm.

The conversion processes mentioned above in the broad sense can both be classified as requiring low or high technology to bring about the conversion process. What this means is that both processes have high and low technology capabilities. For example, we know that biodegradation results from bacterial action on the feed product. If the process proceeds in the presence of oxygen or requires oxygen for a part of the chain of reactions, the end products are carbon dioxide, hydrogen, ammonia gas, heat, other gases and semi-solid matter. In nature we see this process occuring in the compost pile. At a higher technology level the process can be found in the municipal sewage processing plants around the country. Oxygen enhancement can lead to greater proportions of certain end products of commercial value and also a higher cost for product processing. If the bacterial decomposition occurs in the absence of oxygen, the end products are somewhat different. In addition to hydrogen and traces of other gases, combustable methane gas is produced and the whole decomposition process evolves much less heat. The semi-solid matter which is produced in the latter process is rich in nitrogen and is quite valuable as a fertilizer. The biodegradation process without oxygen, anaerobic decomposition, is the process this research will focus on as opposed to aerobic fermentation, the oxygen rich process, since the three major end products will have the greatest value for the least cost. It is also expected that the process adopted will require relatively low technology for readily useful applications on the farm.

The second process, thermal decomposition, can also yield a useful fuel and in fact might be the heat generating process itself. For example, the burning of wood or coal is thermal decomposition with the end products being primarily heat, some gases, and ash or clinkers. To draw a parallel with the aerobic fermentation process mentioned above we find that if we burn our organic matter with plenty of oxygen for the process to go to completion, we will generate much heat, carbon dioxide, particulate matter, and trace gases but no usable fuel. If, however, we limit the availability of oxygen so that total combustion of the feed product does not occur, the elevated temperature and oxygen conditions might be just right to produce relatively little heat, a carbon rich char, a liquid form of hydrocarbons, and burnable gases. Altering the parameters of the processing such as pressure, temperature, oxygen, and feed product will change the relative amounts of the various end products. Except for simple burning of the feed product or primative charcoal production, the thermal decomposition process is a relatively high technology process. A low technology version is considered for a later phase of this research project.

With this background the research program is broken down into five parts with each of the five parts focusing on low technology biodegradation and thermal decomposition processes. The five parts are:

1. Determination and inspection of existing systems to ascertain levels of applicability and user constraints.
2. Collection of user information data such as initial products and desired end products to define a representative set of operating constraints.
3. Design and build one or more energy efficient systems and to evaluate system performance.
4. Field test system.
5. Publicize findings as widely as possible to increase potential user acceptance.

A literature survey and communications with operators in the field resulted in invitations to visit Formosa for biodegradation, the Philippines for low technology thermal decomposition of coconut hulls, Australia for high technology biodegradation, and California for very low technology thermal decomposition. None of these trips were taken due to cost problems. The collection of user information (item 2 above) was planned as a part of the Far West trip and it will have to wait for the time being. Item 3, however, has proceeded quite well for the biodegradtion process. Two systems have been designed and built.

The first system designed and built was of laboratory scale to process five gallons of kitchen waste at a time. The system consisted of a garbage preparer or preprocessor which ground the waste to yield a rich slurry. The second part was a holding tank followed by the digester tank. Coming off the digester was a foam capturing unit and a gas bubbler. The gas bubbler then fed the gas holding system. This system was assembled in one of our solar greenhouses and was loaded with feed product about two months ago. Due to a combination of factors such as wrong pH and gas leaks, the useful methane output from the system is almost nil. The garbage has, however, been converted to a relatively clear liquid with relatively little solid matter remaining. The second system is about ten times as large as the laboratory scale system, consists of fewer component parts, and is designed to operate in the continuous mode. Except for some gas connections it is ready to be loaded. Since temperature is a critical parameter as far as bacteria survival and activity are concerned, the digester is housed in its own small solar greenhouse. Temperature monitoring and pH control are planned for the system as well as utilization of the methane for nightime greenhouse heating and liquid fertilizer incorporation in a limited number of growing experiments.

In the next report period operational characterization of the continuous mode digester is planned for the biodegradation stem of this research. In the thermal decomposition stem contacts with the California group working on the very low technology system will be pursued along with a trip to their installation. It is hoped that before this contract year is completed, that a thermal decomposition system can also be designed and built for laboratory scale operation.

E-21-603

FINAL PROGRESS REPORT

BIOMASS CONVERSION FOR TOTAL ENERGY UTILIZATION

Dr. Dale C. Ray

October 10, 1977

The research program in the study of biomass conversion was directed to the study of the broad spectrum of energy conversion processes which utilize biodegradation or thermal decomposition to convert waste organic matter to useful end products such as fuel gas, fertilizer, or even a food product for lower animals. Due to the curtailment of the project only a portion of the goals were met. A literature search was made to reveal the spectrum of possible conversion proccesses available and who in the world was doing the original work. A decision was made early in the program to concentrate on low technology processes after reviewing the large and expensive projects being carried out in the United States. The survey revealed some rather interesting work being done in the Far East, India, and Africa. Invitations were received to visit the foreign researchers and this was planned for a later phase of this study. During the past few months the project has concentrated on building some integrated units and evaluating their performance. This is the work which will be reported on here.

Possibly the best way to reveal what has been done and the potential for future work is with the aid of the following illustrations or slide figures. Figure 1 shows a rather thin cow, a cow pie, flies, and a puzzled look on the animal's face with an overprint "Methane Gas Generation."

The generation of methane from farm wastes from poor as well as rich farms will be a fuel plus as well as removing a sometimes unwanted by-product of animal husbandry. Figure 2 shows a primitive methane generator, the white object in the middle of the picture, which captures the methane gas in the floating plastic barrel which floats in the liquid slurry of manure. This particular generator is insulated with an expanded plastic foam and is somewhat shielded from the elements in one of the author's early greenhouses. Figure 3 shows the breeding bed for the methane bacteria which are used to seed each load of manure slurry before it is sealed in the digester. This breeding bed is made from the oversized chunks of matter used as feedstock and is located just below the greenhouse exhaust fan, a location needed because of the smell and problems with flies. Figure 4 shows the continuous feed, sealed system designed and built by the author and located in the interstitial greenhouse, previously described. In the foreground is the liquid accumulation container and in the background the 55 gallon tank with gas connections for extracting methane and slurry pumping. Figure 5 shows a second generator located inside one of the small greenhouses. It is located on a rocking platform for load mixing or agitation. Unloading of this system requires that the lid be removed, the system cannot function in the continuous mode of operation. Notice the face mask on the top of the container. This has to be worn for health reasons when loading or unloading the system. Figure 6 shows what the slurry looks like after a few days of operation. A white foam forms on the top with a rather large supply of dead bugs. In addition, active bubbling of gas is also observed. Figure 7 illustrates how the gas from the generator is collected in a truck inner tube which is located in the floor cell of the greenhouse. Higher pressure gas can be obtained by the process shown in Figure 8. This tube is located in the second greenhouse and collects the gas from the generator located in the interstitial greenhouse. Figure 9 shows the residue left in the digester after the methane generation process has ceased. The residue is dried in the greenhouse and would be edible if it weren't primarily wood chips. Figure 10 shows the beginning of either a horizontal digester or a horizontal drier. It was planned that a long chain of solar heated digesters be built utilizing the author's design for a solar drier. Figure 11 also shows a portion of the extension of this project. This is a 250 gallon digester which would have continuous operation monitoring and would afford quantitative comparisons for parameter evaluation.

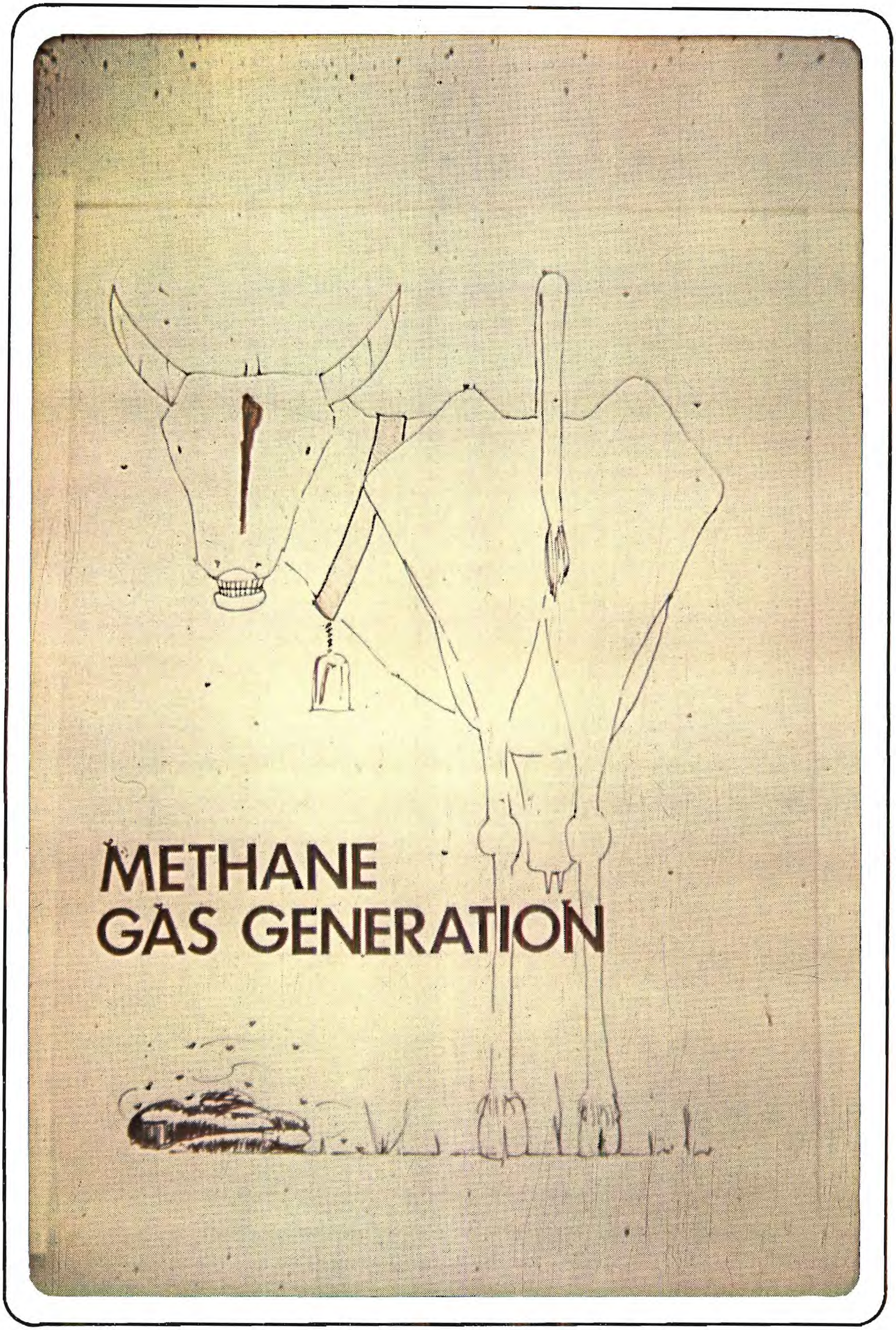

Figure 1. The source of the fuel will also benefit from the waste conversion.

Figure 2. The can-in-the-can form of methane generator where the gas forces the floating container upwards as it is released in the processing.

Figure 3. A continuous supply of methane evolving bacteria live in this container.

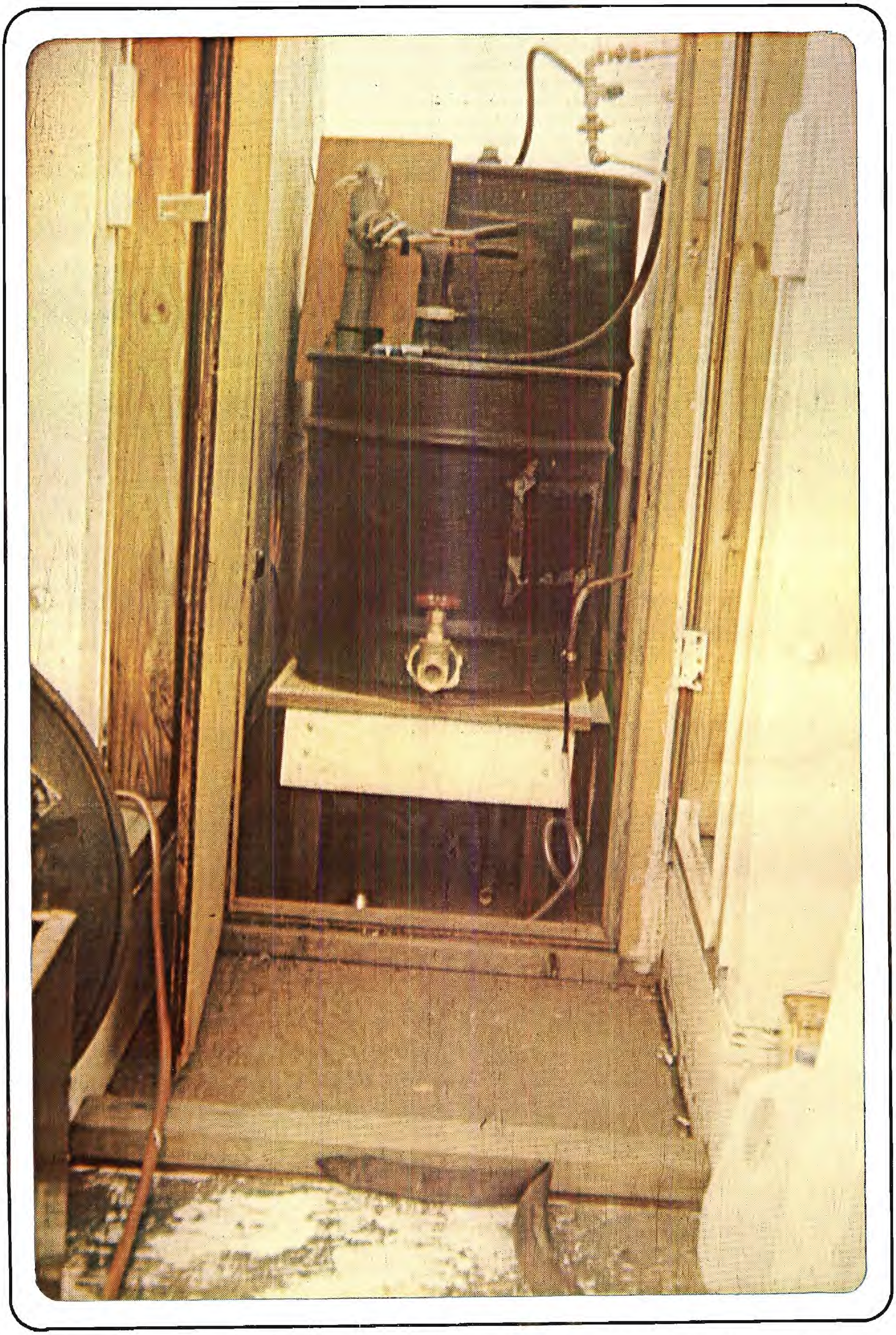

Figure 4. The continuous feed generator located in the interstitial greenhouse.

Figure 5. The batch load generator inside the small greenhouse.

Figure 6. A partially processed slurry in the generator shown in Figure 5.

Figure 7. The gas container for the generator of Figure 5 located in the greenhouse floor well.

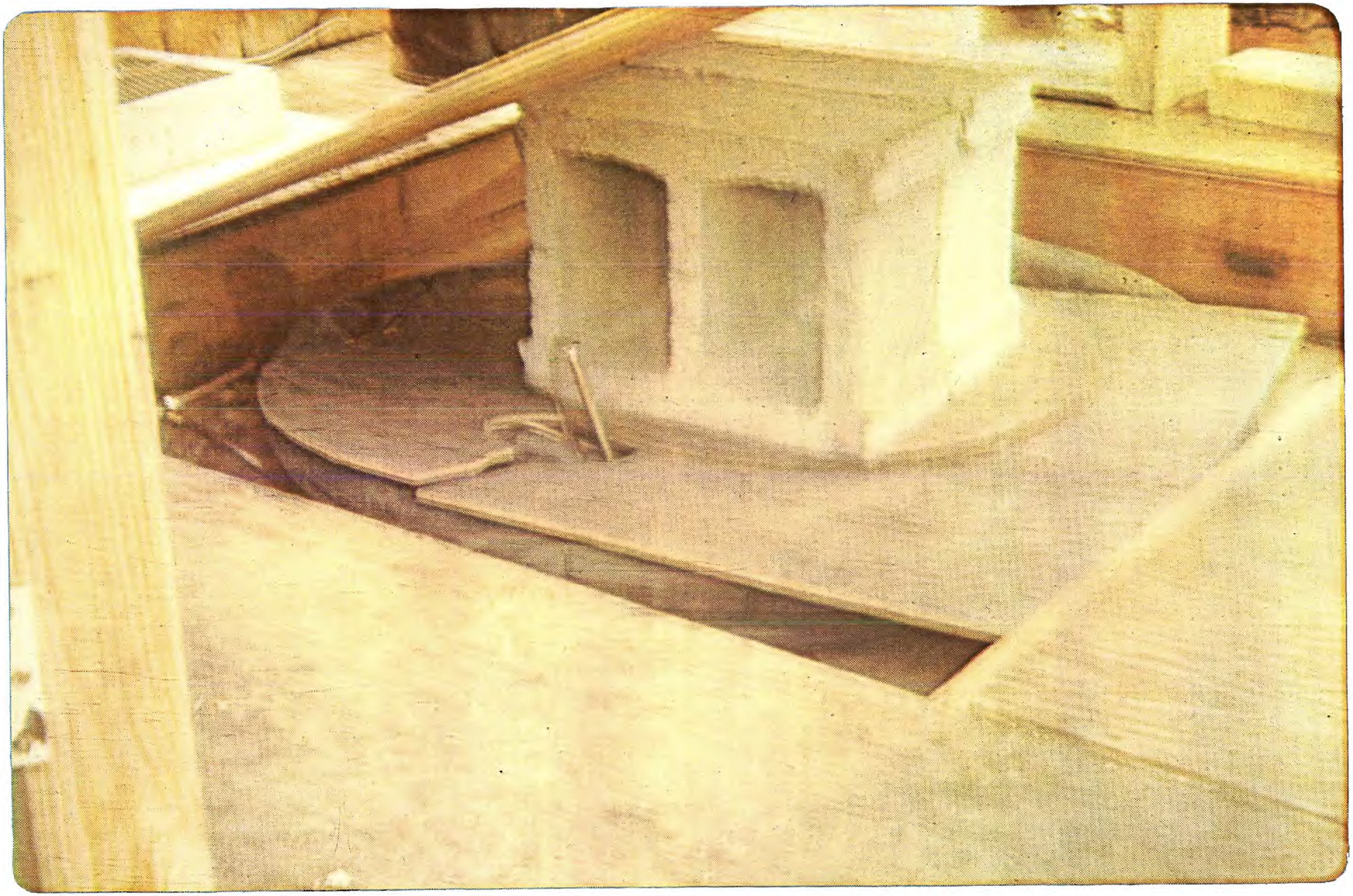

Figure 8. The "pressurized" gas container for the generator of Figure 3.

Figure 9. The dried residue from the first generator run.

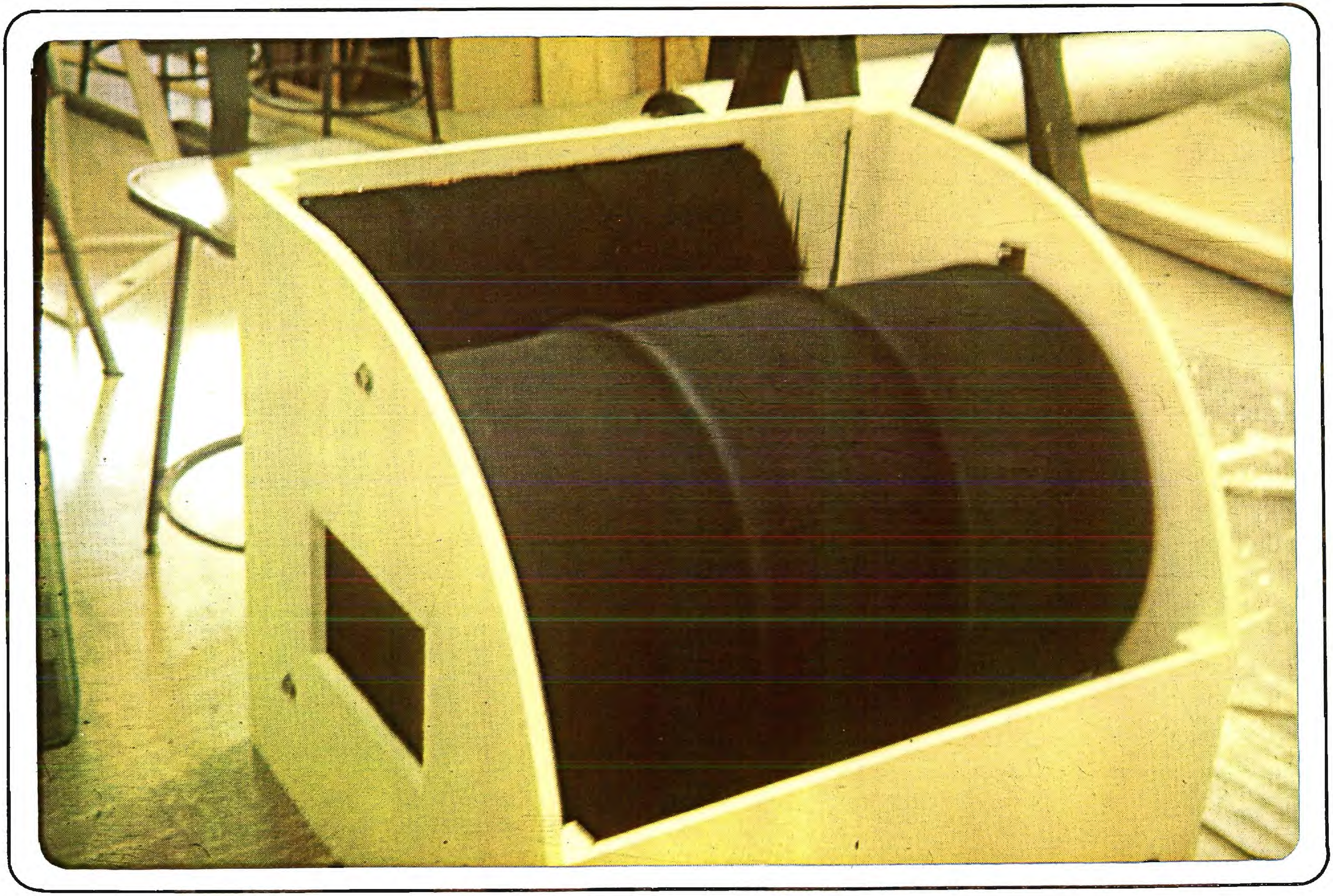

Figure 10. The starting point of a horizontal system of generators would be the author's horizontal drier.

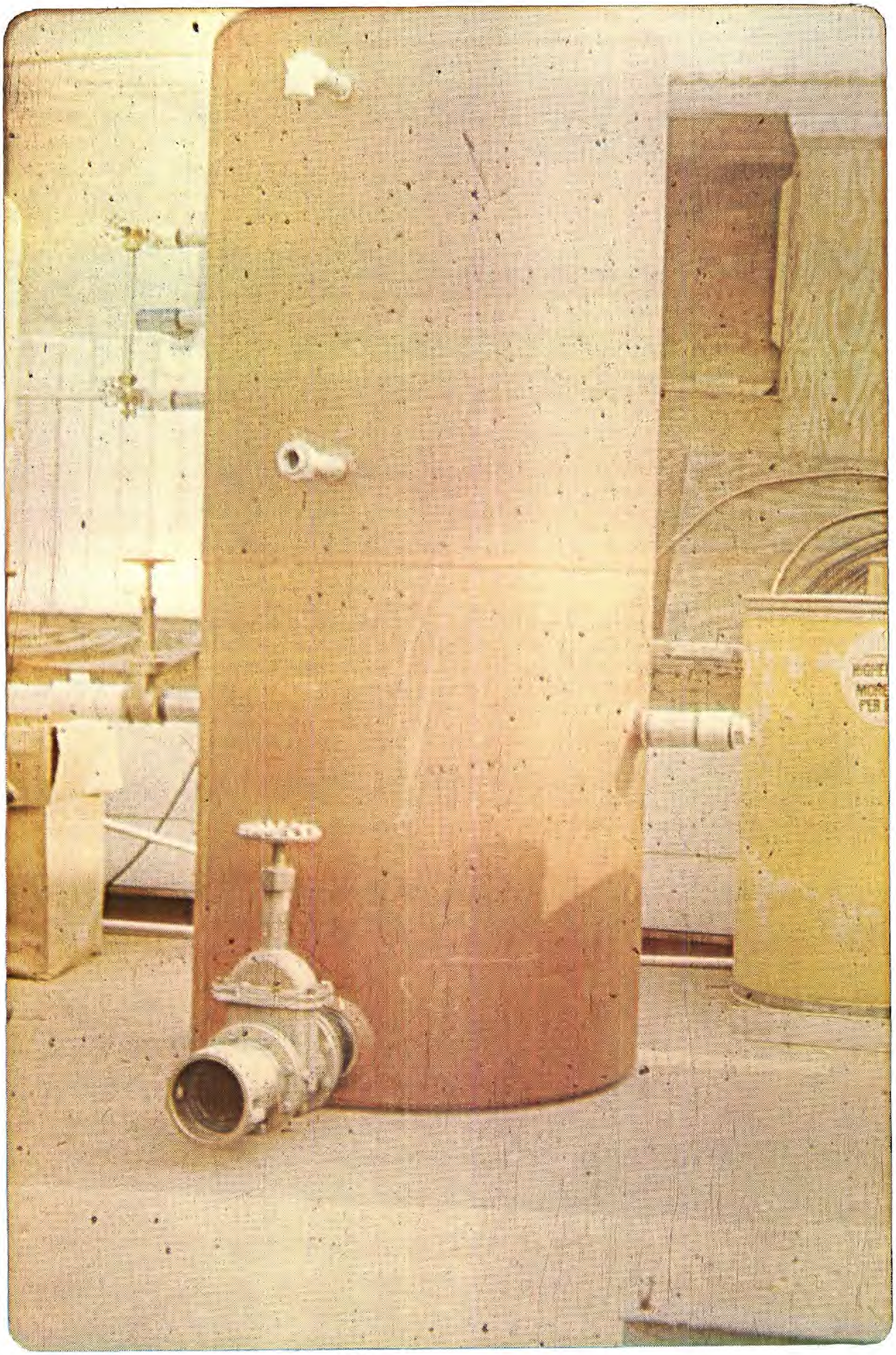

Figure 11. The beginning of a 250 gallon system.